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# VEGETABLES FOR THE HOT, HUMID TROPICS

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## Part 8. Vegetable corns, *Zea mays*

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# VEGETABLES FOR THE HOT, HUMID TROPICS

## Part 8. Vegetable corns, *Zea mays*

BY FRANKLIN W. MARTIN, CHARLES DALOZ, AND MARÍA DEL CARMEN VÉLEZ<sup>1</sup>

### INTRODUCTION

Corn, *Zea mays* L., is an important vegetable as well as an essential grain crop in both the Temperate Zone and the Tropics. Its wide distribution, rapid growth, nutritious and versatile grain, and traditional uses make the grain crop an essential part of agriculture almost everywhere. The use of corn as a vegetable, however, is less intense, and some vegetable uses and vegetable varieties are little known. This partial neglect may be a result of the relatively short shelf life of vegetable corns compared to the excellent storage characteristics of the dried seed, but it is also a result of ignorance, lack of tradition, and lack of appropriate varieties.

Corn is highly recommended as a vegetable for the hot, humid Tropics. It can be produced throughout the year; it grows, flowers, and fruits in all but the heaviest rainy season. Although the dried seed sometimes cannot be produced during rains, the vegetable is not damaged. Furthermore, the vegetable is fairly nutritious, and in its many forms adds welcome variety to the diet.

In the United States, vegetable corn (sweet corn) is second only to the tomato in importance as a vegetable. However, in the Tropics much needs yet to be done to promote the use of vegetable corns.

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<sup>1</sup>Horticulturist, Mayagüez Institute of Tropical Agriculture, Science and Education Administration, U.S. Department of Agriculture, P.O. Box 70, Mayagüez, Puerto Rico 00708; student, Cornell University, Ithaca, N.Y.; and student, University of Puerto Rico at Mayagüez.

# BOTANY

## Taxonomy, Origin, and Distribution

All corns belong to the species *Zea mays* L. (family Graminae), usually called corn in North America, but more frequently called maize elsewhere. The origin of corn in the American subtropics has been extensively studied, and there is now general agreement that corn evolved in Mexico from a primitive wild race that is now extinct. Corn may also have been modified by hybridization with *Tripsacum* species (related perennial grasses) and with teosinte (*Euchlaena mexicana* Schrad), an annual grass from Mexico and Guatemala.

In pre-Columbian times corn was unknown in the Old World but was already widely distributed in the Americas as an important grain crop. Cultivars had been developed that permitted corn production from Long Island, N.Y., through what is now the United States, Mexico, Central America, and most of South America. Pre-Columbian uses of corn included its use as a vegetable as well as a grain.

## Growth Habit and Morphology

Vegetable corns are not different from grain-yielding varieties in growth habit or morphology. All corns are upright, stout, herbaceous, annual grasses with a variable amount of tillering (branching at the base). The long wide leaves are alternate, and their bases sheath the stem. Normal corn is monoecious. The male inflorescence (tassel), borne on the termination of the stem, is a panicle with numerous male flowers occurring in paired spikelets. These pairs are enclosed in modified leaves, the glumes. Within each spikelet are two flowers, each with two stamens. The normal female inflorescence (ear) is produced in the axil of the leaf, and consists of rows of tightly packed ovules, each with a very long stigma (silks). The female spike is covered with modified leaves, the husk. Several such spikes may occur on one main stem or tiller. The seed develops from the ovule and is varied in form, color, and composition. Male flowers usually open and release pollen before the stigmas are receptive. Cross-pollination usually occurs because the light pollen is easily carried by the wind and by gravity to receptive stigmas. Details of corn morphology may be found in Kiesselbach (6).<sup>2</sup>

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<sup>2</sup>Italic numbers in parentheses refer to items in "Literature Cited" at the end of this publication.

## Genetics and Breeding

Because it is easy to control self- and cross-pollination in corn and produce large numbers of seeds, corn is the crop plant whose genetics and cytogenetics have been most investigated. The 10 pairs of chromosomes have all been numbered, drawn, and mapped. More than 500 genes have been identified, and the position of most of these on the chromosomes has been determined. A number of special genetic control systems have been discovered in corn.

Of the many simply inherited characteristics of corn, several are very important in determining the corn's potential use. The most important of these are "starchy," a gene dominant to "sugary," and "opaque<sub>2</sub>," a gene giving floury endosperm in contrast to hard or flinty endosperm. "Starchy" is also dominant to "waxy," a gene that results in starch entirely of amylopectin, which gives the immature ear an attractive taste and texture. Other genes that affect endosperm are "shrunken" and "brittle."

Because some of the genes that affect endosperm traits show a dosage effect in the triploid endosperm, the apparent dominance of a simply inherited character may be different in reciprocal crosses. The effect of the male genetic constitution on the endosperm or other seed characteristics is called *xenia*, a special phenomenon important to plant breeders. For example, when sweet corn is accidentally pollinated by even a few grains of pollen from starchy corn, the resulting grains are starchy and detract from the value of the sweet corn.

Corn plants in a normal outcrossing population are very heterozygous as a consequence of almost constant outcrossing. Thus, improvement of corn by mass selection of apparently superior plants has been difficult, even when the superior plants are first tested for their ability to yield superior progeny. In spite of wide-scale efforts to improve corn by plant breeding, real progress was difficult until the advent of hybrid corn. Today, in highly developed countries, very little corn is grown that is not hybrid corn, but tropical vegetable corns, often grown on a small scale or confined to a region, are still often open-pollinated or normal varieties.

Hybrid corn depends first on the production of inbreds. By inbreeding, homozygosity (genetic stability) is established, and when inbreds are crossed, their progeny are usually uniform and vigorous. Crossing two hybrids, each from two inbreds (the double-cross technique), makes large quantities of vigorous seed available. Genetic mechanisms, chiefly cytoplasmic male sterility, facilitate field crossing. An entire industry has developed around this process of producing double-cross hybrid seed.

## VARIETIES

Although the immature ears of all corns can be used as vegetables some corns are better than others for this purpose. Classification of corn by type depends largely on the seed endosperm and its composition, especially with respect to protein and starch.

*Flint* corn has a particularly hard and glossy endosperm associated with the protein zein. Only a small proportion of the seed is soft and starchy. In *dent* corn the vitreous endosperm is less extensive and soft starch extends to the tip. When the kernel dries a characteristic dent is formed at the tip. In *floury* corn all of the endosperm is soft or floury, and the grains are therefore opaque. In *waxy* corn, the endosperm consists principally of the waxy-appearing starch amylopectin. In *sweet corn*, sugars of the developing endosperm are converted to starch much more slowly than in the case of other corns mentioned above. The endosperm shrinks when the seed dries, resulting in a vitreous translucent endosperm. Flint and dent corns are used infrequently as vegetables. Floury and waxy corns are often used as vegetables. Sweet corns are used exclusively as vegetables.

### Sweet Corns

The best tropical sweet corn varieties known to the authors are listed in table 1. Most of these varieties owe their sweetness to the gene "sugary," the common source of sweetness. The variety 'Florida Sweet' makes use of "shrunk<sub>2</sub>," another factor leading to increased sweetness but decreased seed viability and poor seedling vigor. New types of sweet corn called supersweet, which owe their sweetness to "brittle<sub>1</sub>," "brittle<sub>2</sub>," and "shrunk<sub>2</sub>," have been developed in Hawaii, where they have been readily accepted (2). In addition to their superior sweetness, they can be picked over a longer period of time and they last longer once picked. Recently, an entirely new sweet corn has been bred in which sweetness is produced by "sugary," but other genes delay the conversion of sugar to starch, thus extending the lifetime of the sweetness. Varieties include 'Tendertreat', 'Kandy Korn', 'Mainliner', and 'Miracle'. These have not yet been adapted to the Tropics.

'Black Mexican' is a very old, traditional sweet corn variety. 'USDA-34' is a synthetic variety developed in Puerto Rico that has been used widely. 'Suresweet' is an excellent, more uniform, widely adapted variety that was selected from 'USDA-34'. Combining sweetness with the "opaque<sub>2</sub>" character may provide more highly nutritious sweet corns for the Tropics. For example, 'Nutrimaiz', developed in Brazil and used as a vegetable corn, is rich in protein; its level of the essential amino acid lysine is almost twice that of normal sweet corn.

Sweet corn is highly successful in Puerto Rico and can be planted year round. In extensive trials, two Hawaiian varieties, 'Hawaii 68'

and 'Hawaiian Hybrid' have proved to be the best in yields (4, 7), followed by the locally developed varieties 'USDA-34' and 'PR-50'. Yield varies throughout the season. Exceptionally good yields (40,000 or more marketable ears per hectare) have been obtained using fertilizers to achieve optimum growth and using chemical weed and pest controls. The characteristics and yields of some sweet and other varieties tested at Mayagüez during the summer rainy season are given in table 2. The supersweet and "sugary extender" corns have not yet been tried in Puerto Rico.

### Other Vegetable Corns

The unripe ears of a seemingly unlimited number of varieties of corn, mostly field corns, are used as a vegetable called choclo throughout South and Central America. Flint and dent varieties are used for this purpose. In Peru, Colombia, and Ecuador, varieties of floury corn with very large kernels are successful and are grown extensively; the kernels are soft and starchy when boiled, and they retain some sweetness. In Peru the varieties 'VS-2', 'INIAP 515', and 'Pichilingue 513' are recommended for this purpose.

A collection of corns was tested at the Mayagüez Institute of

TABLE 1.—*Tropical sweet corn varieties*

Variety	Kind of variety	Gene causing sweetness	Origin
'Amarelo' . . . . .	( <sup>1</sup> ) . . . . .	Sugary . . . . .	Brazil.
'Black Mexican' . . . . .	Open-pollinated . . . . .	Sugary <sub>2</sub> . . . . .	( <sup>1</sup> ).
'Branco' . . . . .	( <sup>1</sup> ) . . . . .	Sugary . . . . .	Brazil.
'Chinta' . . . . .	Composite . . . . .	Sugary . . . . .	Malaysia.
'Cubano' . . . . .	Open-pollinated . . . . .	Sugary . . . . .	Brazil.
'Doce de Cuba' . . . . .	Open-pollinated . . . . .	Sugary . . . . .	Brazil.
'Florida Sweet' . . . . .	Hybrid . . . . .	Shrunken <sub>2</sub> . . . . .	Florida.
'Gold Cup' . . . . .	Hybrid . . . . .	Sugary . . . . .	U.S.A.
'Hawaii 68' (Tropic 3) . . . . .	Hybrid . . . . .	Sugary . . . . .	Hawaii.
'Hawaiian Hybrid' . . . . .	Hybrid . . . . .	Sugary . . . . .	Hawaii.
'Hawaiian Sugar' . . . . .	Open-pollinated . . . . .	Sugary . . . . .	Hawaii.
'Hawaiian Supersweet #6' . . . . .	Composite . . . . .	Brittle <sub>2</sub> . . . . .	Hawaii.
'Hawaiian Supersweet #8' . . . . .	Composite . . . . .	Shrunken <sub>2</sub> , opaque <sub>2</sub> . . . . .	Hawaii.
'Hawaiian Supersweet #9' . . . . .	Composite . . . . .	Brittle <sub>1</sub> . . . . .	Hawaii.
'Medellin' . . . . .	Composite . . . . .	Sugary . . . . .	Colombia.
'Nutrimaiz' . . . . .	Composite . . . . .	Sugary, opaque <sub>2</sub> . . . . .	Guatemala.
'PR-50' . . . . .	Composite . . . . .	Sugary . . . . .	Puerto Rico.
'Suresweet' . . . . .	Composite . . . . .	Sugary . . . . .	Puerto Rico.
'Tuxpeño Dulce' . . . . .	Composite . . . . .	Sugary . . . . .	Mexico.
'USDA-34' . . . . .	Composite . . . . .	Sugary . . . . .	Puerto Rico.

<sup>1</sup>Information not available to authors.

TABLE 2. — *Characteristics and yields of some corns tested as vegetables at Mayagüez, P.R., during the summer rainy season*

Variety	Source	Seed type	Shape and color of ear	Days to maturity	Cooking time (min)	Earworm resistance <sup>1</sup>	Value as vegetable <sup>2</sup>	Yield (ears/ha)
'Chulo'	Puerto Rico	Dent	Tapered, yellow	76	32	4	4	24,100
'Cubano'	Brazil	Sweet	Cylindrical, yellow	76	8	3	4	10,300
'Curagua Pop'	Chili	Pop	Tapered, white	68	(3)	1	1	17,200
'Diente de Caballo'	Puerto Rico	Dent	Cylindrical, white	76	32	3	4	12,900
'Doce de Cuba'	Brazil	Sweet	Tapered, yellow	76	8	4	4	73,200
'Gold Cup'	U.S.A.	Sweet	Tapered, yellow	76	8	3	3	17,200
'Ibadan A'	Nigeria	Dent	Cylindrical, yellow	87	32	4	5	18,100
'Ibadan B'	Nigeria	Dent	Tapered, yellow	76	32	3	4	26,700
'INIAP 128'	Ecuador	Dent	Cylindrical, yellow	74	32	4	5	15,500
'Mayorbela'	Puerto Rico	Sweet	Tapered, yellow	76	32	3	3	18,000
'Medellin'	Colombia	Sweet	Tapered, yellow	76	8	3	5	12,000
'Ohio S-5 Mass'	U.S.A.	Dent	Tapered, yellow	76	32	1	2-5	23,600
'Opaque <sub>2</sub> '	Mexico	Floury	Tapered, yellow	76	32	4	5	28,400
'Philippine White Wax'	Philippines	Waxy	Cylindrical, yellow	68	32	4	5	17,200
'PR-3'	Puerto Rico	Dent	Cylindrical, white	76	25	4	4	22,400
'PR-50'	Puerto Rico	Sweet	Tapered, yellow	76	8	4	5	24,098
'Suresweet'	Puerto Rico	Sweet	Tapered, yellow	76	8	3	5	27,500
'Tropic-3'	U.S.A.	Sweet	Tapered, yellow	72	8	4	3	29,300
'USDA-34'	Puerto Rico	Sweet	Cylindrical, yellow	76	8	4	4	25,800

<sup>1</sup>Rated from 1 (little or no resistance) to 5 (high resistance).<sup>2</sup>Rated from 1 (little value) to 5 (high value).<sup>3</sup>Data not available to authors.

Tropical Agriculture (MITA) as vegetables. The ears were harvested in several stages while still green, boiled until tender, eaten, and rated as vegetables. The panel contained persons used to a diet heavy in farinaceous foods, as well as persons familiar with sweet corn at its best. The results of this test are included in table 2. Persons who eat large quantities of farinaceous foods considered even ears from flint varieties good as vegetables; they found the rather coarse texture and heavy starchy taste natural and desirable. Such persons did not favor sweet corn over other corn used as vegetables. Persons who had been accustomed to the flavor and characteristics usually sought in sweet corn preferred the sweet corn and rejected the other vegetable corns.

All of the corns tested as vegetables yielded well even during the rainy season (table 2). The few ears that were left for observation did not produce mature seed of high quality, but even though these corns sometimes cannot be grown for their grains during the rainy season, they can be grown as vegetables.

## CULTIVATION

### Climatic Requirements

Corn is a hot-weather crop; it cannot usually be grown satisfactorily during cool weather (15°-20° C). Thus, although corn is grown almost everywhere in the Tropics, it is less successful at high altitudes because of low temperatures. Sweet corn will also fail to produce well when temperatures are high if humidities are very low because pollen is then damaged.

Corn will be dwarfed if water is not available to its roots at all times during the growing season. It is difficult to grow in dry regions or during dry seasons unless irrigation water is supplied, and water is especially critical in the few weeks just prior to silking.

Even though corn can withstand the heavy monsoon rains that severely damage other crops, continued flooding of the roots reduces growth. (Where possible, some protection against flooding is achieved by planting on ridges or hills.) And although corn seed will not mature properly during rainy seasons and must be harvested and dried under protected conditions, the immature corn used as a vegetable is seldom damaged by rains. Of course, storms can damage corn indirectly by softening the soil around roots, allowing winds to topple the plants.

Corn grows very rapidly and requires an open, aerated, highly fertile soil, and maximum sunshine. Of course, some varieties are daylength sensitive, and some of these may flower prematurely (when plants are still small) during the tropical summer, and prematurity is even more severe during the tropical winter.

Corn is a highly adaptable species, but its characteristics (size, form, and flowering date, for example) will be affected by its environment. Of the thousands of varieties of corn, some are better adapted than others for any particular environment. Growing corn successfully includes finding the right variety for the environment it is to be grown in.

### **Soils and Preparation**

Corn can be grown in practically any soil if its fertility is high enough, if the soil is well loosened and aerated, and if moisture is not a limiting factor. Corn produces earlier on sandy soils than on others. On flat fields not subject to erosion, it is best to plow deep and divide the soil in the seedbed very finely. Where soil drainage and aeration are adequate and erosion may be a problem, minimum tillage and weed elimination with herbicides is often better. On steep slopes it may be necessary to plow along the contour or plant individual hills. In dry areas corn may be planted in holes or furrows to better use available moisture. In West Africa corn is often planted on relatively high mounds (0.5 meter or more) to avoid damage from flooding.

Cornfields should be well fertilized before planting. Nitrogen is usually the most necessary nutrient (60 to 90 kilograms of N per hectare is generally desirable). On tropical soils with a pH of 5.0 or less, lime should be applied several weeks before planting (at least 2 to 3 tonnes per hectare). Phosphate fertilizer is also necessary in most tropical soils. Mineral fertilizer is usually more effective when placed by machine in a band (5 centimeters deep) parallel to the row of plants (5 centimeters to the side). Broadcast mineral fertilizer is often used by weeds or otherwise wasted. Organic material such as well-rotted manure (10 to 20 tonnes per hectare) can be mixed with the soil. Holes for planting can also be filled with mixed soil and compost. Since fertilizer needs vary so widely depending on location, locally developed information should be consulted about what fertilizer to choose and how much to apply.

Weeds are often easiest to control by preplanting applications of herbicides, but these must be applied carefully according to local laws and the manufacturer's instructions.

### **Planting**

Corn seeds should be dried before storage, maintained at a cool temperature (10° C), and kept under dry conditions. The germinability of sweet corn seed decreases fairly rapidly. Each lot of seed should be given a germination test before planting so that enough seed

TABLE 3.—*Amount of corn seed required for various plant-spacing intervals*

Spacing (cm)	Seed required (kg/ha)
50 × 50	6
60 × 60	4
80 × 25	7
30 × 100	5

can be sown to compensate for poor germination. Seed more than 2 years old should not be planted. (Other vegetable corn seeds are more viable and long lived than sweet corn seed.)

Sweet corns should not be planted too close to other corns lest cross-pollination occur, thus damaging the quality of the ears. Where soil moisture and fertility are optimum, plants can be spaced at smaller intervals than they can under limiting circumstances; plants should be widely spaced if water or fertility resources are limited. Under optimum conditions, spacing can be decreased until competition between plants reduces yields. As a guide for first planting, follow local practices, including those used with field corn. Three to eight plants per square meter is common.

The amount of highly viable seed (80%-90%) required for various spacings is suggested in table 3. Seeds should be planted at a depth from 2 centimeters (in wet heavy soils) to 4 centimeters (in drier and lighter soils). Seeds may be treated with chemicals before planting to reduce the incidence of seedling diseases, but use of chemicals is often controlled by law. Local laws and the manufacturer's suggestions should be carefully followed when applying chemicals. If natural rainfall is light after seeding, plots should be irrigated to insure uniform germination.

### Postplanting Care

About 4 weeks after planting, it is often desirable to add a second application of mineral fertilizer, which is usually scattered around each plant, but can also be imbedded in the soil with a hoe. Purpling of the foliage is a sign of phosphate deficiency, which can be corrected with extra phosphate fertilizer. Slow growth and yellow foliage usually indicate nitrogen deficiency.

Water should be available to the roots continuously; in dry conditions it will probably be necessary to apply water every 4 to 14 days, depending on the ability of the soil to retain water.

## PESTS AND DISEASES

Because corn is so widely distributed, it is affected by a large number of pests and diseases—perhaps 300 or more. Some are almost universal, and others are rare. With few exceptions, vegetable corn should not be treated for pests or diseases until they appear or until a strong threat (appearance of many pests or diseases in adjacent fields) appears. One such exception in Puerto Rico is the armyworm, *Pseudaletia unipuncta* (Haworth), a pest that will damage almost every cornfield if precautions are not taken. Because there is such a large number of pests and diseases that afflict corn, only a few of the most important will be mentioned here. Good pest control begins with accurate identification of the pest or disease, choice of appropriate control measures, and initiation of the controls on time. Since chemical controls are subject to local laws, we cannot recommend specific chemicals; instead, we will list the most important pests and diseases found in the Tropics.

Armyworms such as the yellowstriped armyworm, *Spodoptera ornithogalli* (Guenée), and the black armyworm, *Laphygma exempta* Walker, are moth larvae that usually attack vegetable corn when the plants are very young. A pest of other grasses, armyworms are very widespread, and while their numbers may be subject to seasonal fluctuation, they are present year round in some areas. Damage from armyworms is seen as irregular holes and cutaway areas of the leaves, especially in the young leaves emerging from the center of the plant. The caterpillars can often be seen within the furled leaves, where they feed heavily and may even destroy the growing tip. In small plantings it is sometimes possible to destroy an infestation by squeezing gently the column of unfurled leaves of affected plants. As plants develop, they usually acquire a resistance, but in late attacks, the tassel may be severely damaged as well.

Larvae of other moths bore into stems and ears. The sugarcane borer, *Diatraea saccharalis* (Fabricius), tunnels into the stem and reduces growth severely. The European corn borer, *Ostrinia nubilalis* (Hübner), less common in the Tropics, bores in and through the stalk, causing breakage or poor growth of stalk and ears. It can also bore into the ear. The corn earworm, *Heliothis zea* (Boddie), a universally occurring pest, enters the ear itself and damages the kernel. It can also cause severe whorl damage in young corn. The corn silk maggot, *Euxesta stimatias* Loew, is less common but can be damaging at times. The rice weevil, *Sitophilus oryzae* (Linnaeus), sometimes lays eggs in individual grains. During seed storage, the growing weevil then destroys most of the germ and endosperm.

Corn varieties differ in their resistance to these insects. Varieties with heavy husks that extend well beyond the tip of the ear are attacked less frequently than less-protected varieties. Trials are

desirable not only to identify locally adapted varieties but also to assess their insect resistance. Control of insects in commercial plantings usually requires chemical sprays, and calls for extreme care to assure that sprays are used legally and according to label specifications to avoid pesticide residues for humans.

Diseases of vegetable corn in the Tropics vary widely. Rust caused by *Puccinia polysora* Underw. is common in Puerto Rico. Its principal symptoms are small, elongated, rust-colored blisters on the underside of the leaves that on breaking leave irregular spots. There are varieties that are partially resistant to this disease.

Fungi of the genus *Helminthosporium* attack corn leaves, producing many circular or elongated spots. Where the diseases are intensive, it is difficult to produce sweet corn. The best protection is to select resistant varieties. Downy mildew, caused by *Sclerospora* spp., is often found as yellowing areas on leaves of young seedlings; the downy symptom is seen at night on the underside of leaves. Fungus diseases can often be controlled by chemical sprays, the risks of which have been previously mentioned.

Cultural practices can reduce the incidence of disease. Seeds for replanting should come only from disease-free plants. When disease is present, walking through the field should be minimized, as this spreads the disease. After harvest, all plant residues should be destroyed by feeding to animals, plowing under, burning, or composting. Because diseases and insects from earlier plots are readily transferred to subsequent plantings, sites used to grow vegetable corns should be planted to several generations of other crops before replanting.

## HARVEST

For nonsweet vegetable corns, harvesttime is not critical; any particular ear can be harvested at any time during a period of a week or more. Sweet corn, on the other hand, must be harvested at its peak (a period lasting from 1 to 3 days) in order to achieve maximum sweetness. As the kernel grows, the endosperm is a liquid that gradually solidifies; sweet corn is at its best when the liquid is thick and opaque, just before hardening begins. At this time the silks have turned brown, the husks are well filled, and the ears feel solid. Harvesting sweet corn at the right stage requires careful observation and judgment acquired from experience, but sweet corn is usually ready to harvest 15 to 20 days after silking.

Harvesting itself consists of snapping off the ears with a quick downward movement and a twist. Harvested ears should be kept out of the sunlight, packed in light boxes with good aeration, and transported to an area where they can be cooled as quickly as possible.

## POSTHARVEST CONSIDERATIONS

### Storage

Vegetable corns, especially sweet corns, must be refrigerated or processed as soon as possible. Loss of sweetness begins as soon as the ear of corn is removed from the plant, and when the sun warms harvested ears, loss of sugar is accelerated. Even a few hours' delay results in greatly reduced eating quality. Therefore, sweet corns should be picked as close to cooking as possible. If it can not be cooked right away, sweet corn should be refrigerated as quickly as possible. For maximum flavor retention, sweet corn can be frozen in its husk and maintained several weeks in this form. But refrigerated and frozen corns will also deteriorate, and these controls are suggested only for short-term storage. Longer storage should be attempted by canning or by blanching and freezing. Other forms of vegetable corn do not deteriorate as fast as sweet corn and can be maintained several days without refrigeration; nevertheless, best quality is obtained by harvesting corn just before use.

The storability of sweet corn at cool temperatures ( $10^{\circ}\text{C}$ ) is greater if it has the "shrunken<sub>2</sub>" gene. When this gene is present in the endosperm, the sugars remain as such for a longer period of time, and ears of corn can be considered edible for up to 9 days, compared to 3 or 4 days for comparable varieties whose sweetness is based on the "sugary" gene (9).

### Uses

Vegetable corns are occasionally used for their tiny, immature ears that are tender enough to be eaten raw, including the cob. These are attractive in appearance and flavor and can be served in salads or alone, raw, pickled, or cooked. In Taiwan they are grown commercially and canned for export.

Sweet corn is almost always boiled or steamed and served on the cob or cut free from the cob. When cut from the cob, the corn can be used in a wide variety of vegetable mixtures, soups, or stews. Cooking time should be short, but will depend on whether the corn is garden fresh, cooled, or frozen. After removing the husks, garden-fresh corn can be ready to eat after 5 minutes of boiling or 10 minutes of steaming; the less fresh the corn is, the longer it must be cooked.

Choclo or other forms of nonsweet vegetable corn are usually boiled for a longer time, often more than 30 minutes. More mature corns require longer periods of boiling. Nonsweet vegetable corns are served the same way as sweet corns.

The use of nonsweet "opaque<sub>2</sub>" corn as a vegetable is still a novelty, but experiments at MITA suggest that it is acceptable as a vegetable

corn. Its use in this form should be promoted in order to increase variety in the diet and to use this nutritious food more.

### Nutritional Value

The nutritional composition of some sweet corns and other vegetable corns is given in table 4. The data are scanty, and better comparisons of nutritional values under uniform conditions are desirable. The nutritive value of corn depends on maturity at picking and how it is subsequently handled and stored, but some facts are evident. Nonsweet vegetable corns contain a large amount of starch (hence their starchy taste) and can contribute large numbers of calories to the diet. They also contribute some protein, which is a much more nutritious protein than usual if the corn has the “opaque<sub>2</sub>” gene. Traditional sweet corns contain somewhat more sugar and much less starch than nonsweet vegetable corns, if they are picked in the right stage. Supersweet corns contain the highest amounts of sugars, very good quantities of protein, and almost no starch. They are therefore highly nutritious as well as appealing to the palate.

The protein of most corns is limited in value because of relatively

TABLE 4.—*Nutritional composition of some vegetable corns*  
[Per 100 grams of edible matter]

Component		Sweet corn	Nonsweet corn	Supersweet corn	Sugary <sub>2</sub>	Opaque <sub>2</sub>
Volume	cup	0.67				
Water	g	76.5	56			
Energy	cal	83	173			
Principal nutrients:						
Total sugars	g	5.5		40	2.2	
Carbohydrates	g	19	39.0		36.9	
Fat	g	1.0	1.7			
Protein	g	3.2	4.6	14.5	4.7	
Minerals:						
Calcium	mg	3	13			
Iron	mg	0.6	1.4			
Phosphorus	mg	90	150			
Vitamins:						
Vitamin A	IU	400	265			
Vitamin B <sub>1</sub>	mg	0.11	0.13			
Vitamin B <sub>2</sub>	mg	0.10	0.10			
Vitamin B <sub>3</sub>	mg	1.3	0.09			
Vitamin C	mg	7	0.4			
Amino acids:						
Lysine	(1)	3.0	2.4		5.4	4.6
Tryptophan	(1)	0.59	0.37		0.85	1.17

<sup>1</sup>Mg per 100 mg amino acids.  
Sources: Adams (1), Dirigente Rural (3), Intengan (5).

low proportions of lysine. The protein of "opaque<sub>2</sub>" corns and some supersweet corns is much better because they have higher percentages of lysine. The presence of another gene, "floury<sub>2</sub>," also increases lysine content, but preliminary attempts to use this gene to produce more nutritious corn have led to the conclusion that the "opaque<sub>2</sub>" gene is more useful (8). The large-seeded floury corns of the Andean highlands are probably a different "floury" type; unpublished work at CIMMYT suggests that they do not have any special nutritional value for humans.

## FUTURE PROSPECTS AND RECOMMENDATIONS

Corn will doubtless continue to be used more for its dry seed than for its immature ears as vegetables because the dry seeds are a compact, storable food. Yet there is ample opportunity to extend the use of corn by promoting its vegetable uses where these are not widely known and by disseminating new, improved varieties. Sweet corns should be considered special vegetable varieties; they should not replace entirely the starchy ears, which have a distinct, different value in the diet. Supersweet corns (which appeal to a current trend that favors more sugar in the diet) may be especially appreciated as luxury vegetables. The several uses and many cultivars of corn provide opportunities for increased and more varied commercial and home production, as well as for variety in the diet.

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